

March 11, 1969

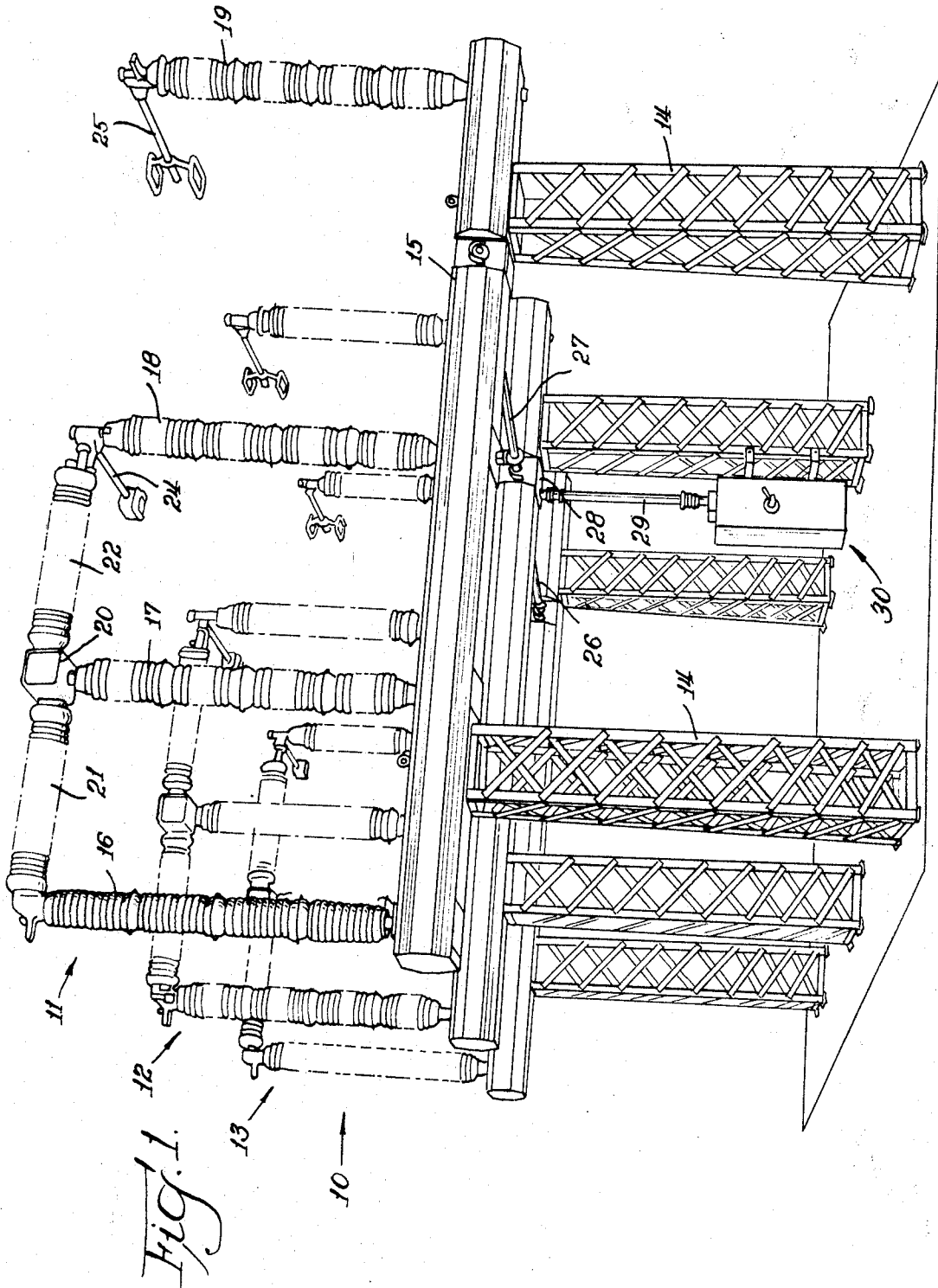
D. M. EVANS ET AL

3,432,780

MOTOR-DRIVEN OPERATOR FOR HIGH VOLTAGE SWITCH

Filed July 6, 1967

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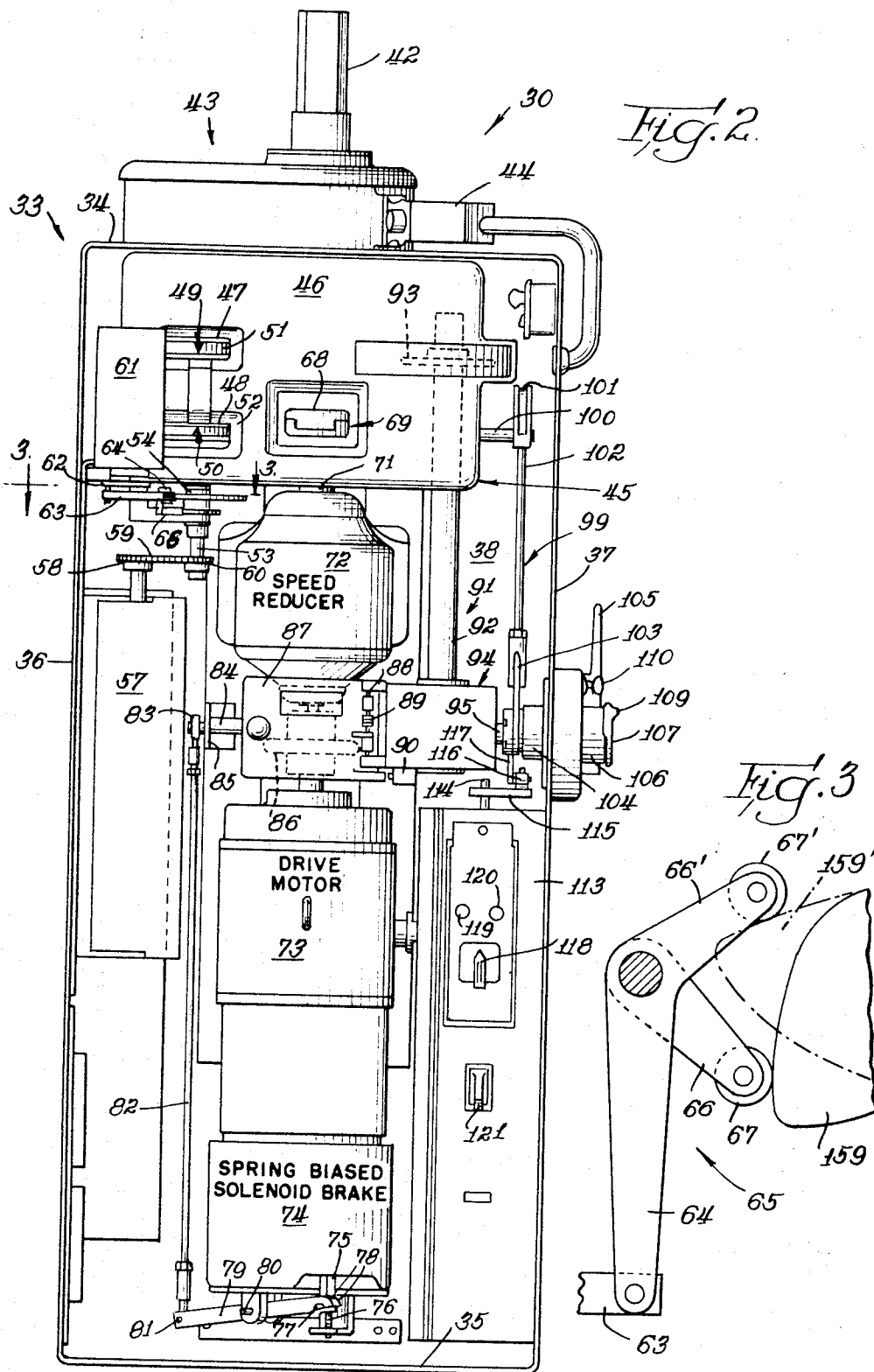
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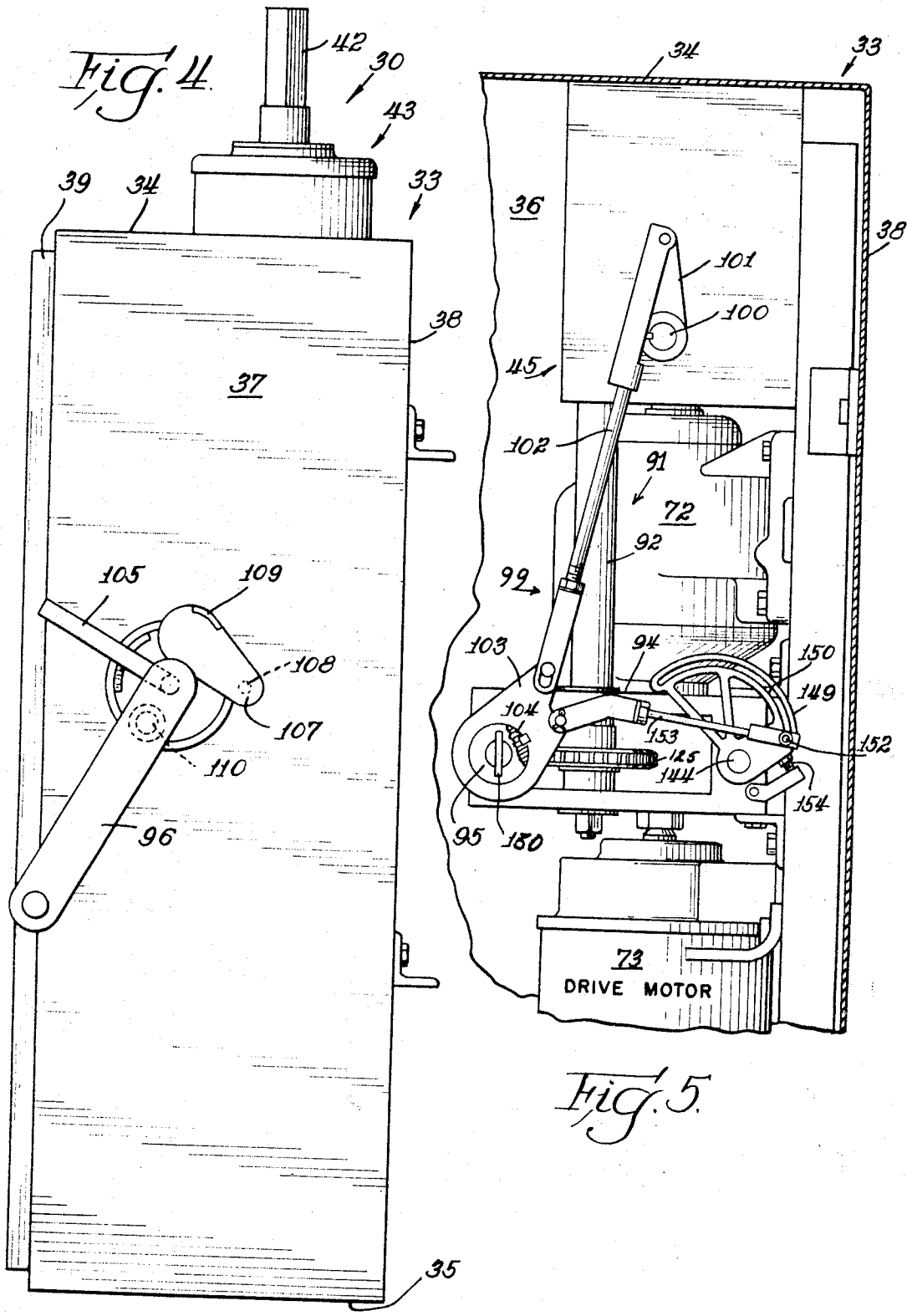
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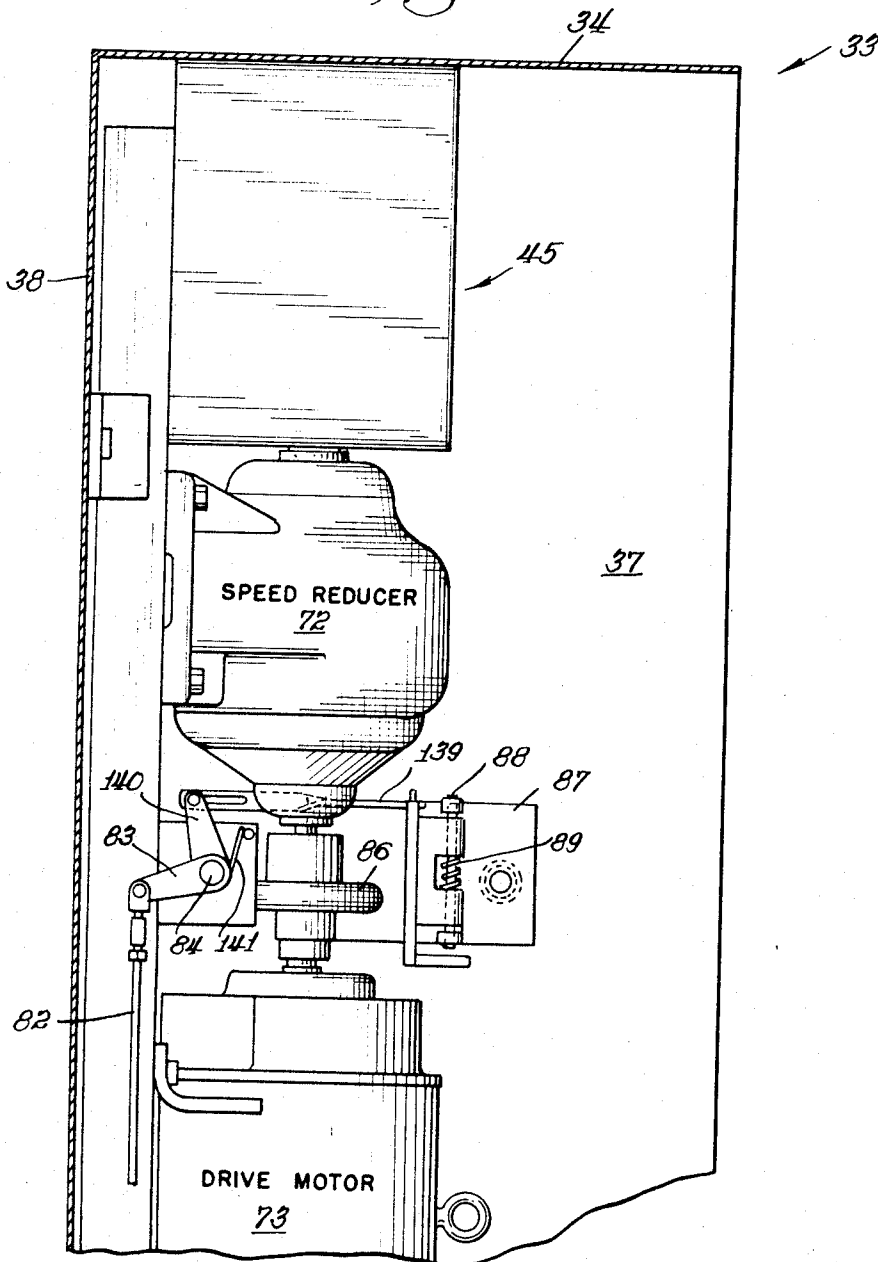
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Fig. 6



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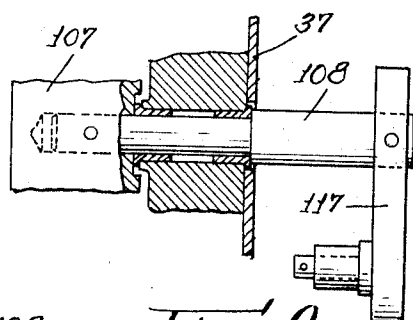
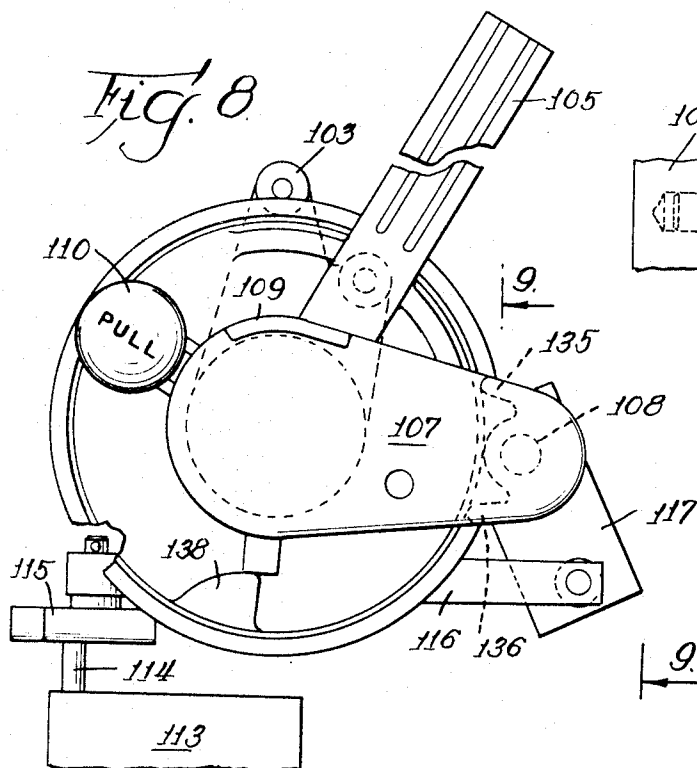
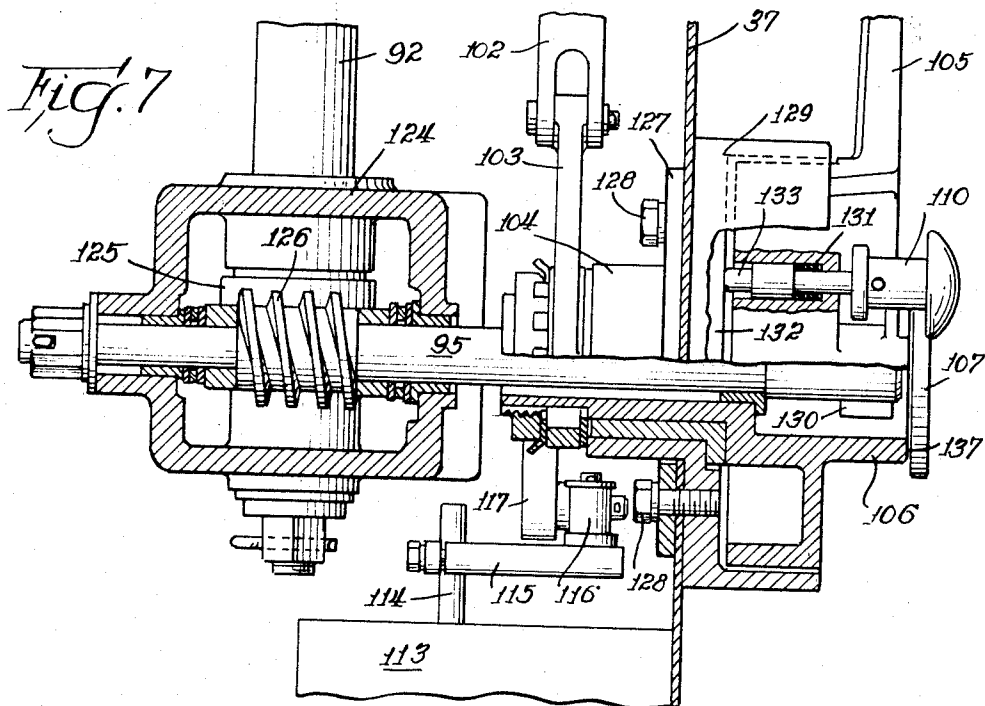
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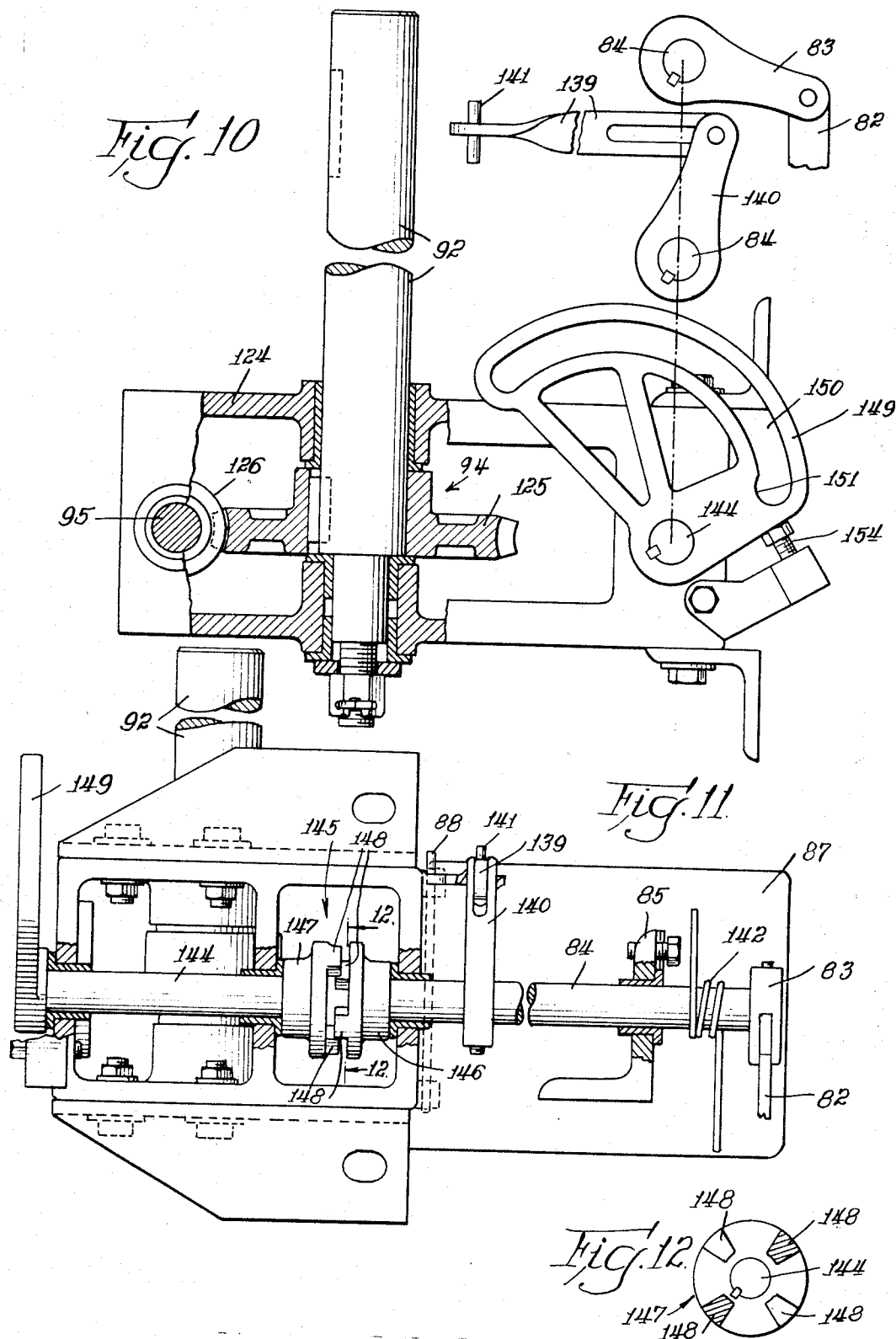
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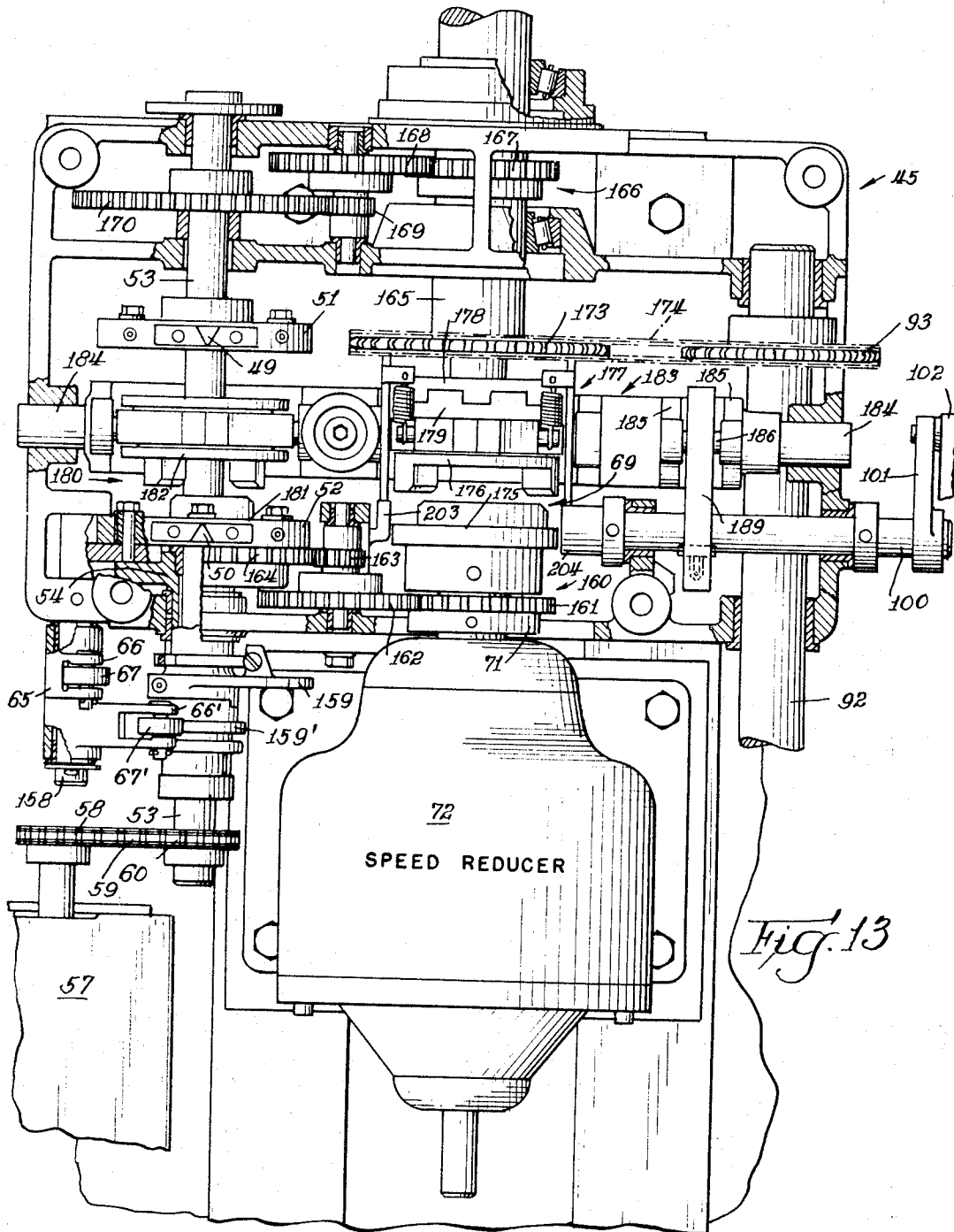
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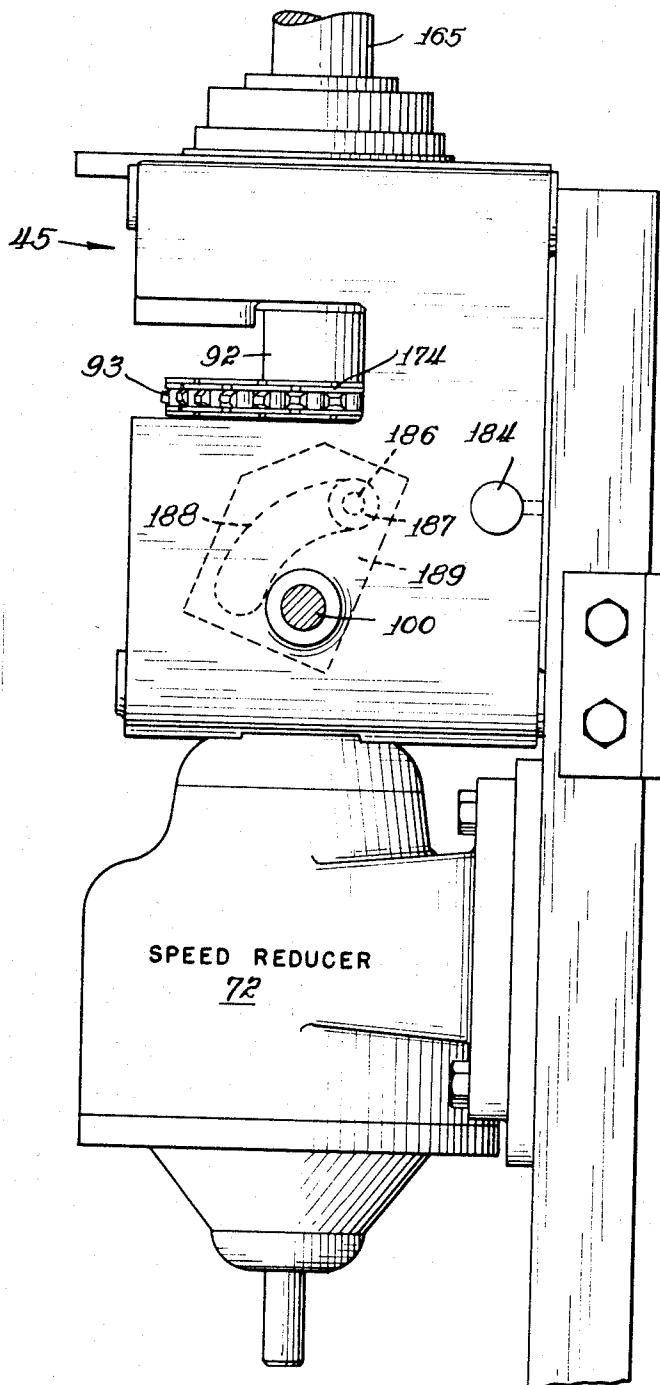


Fig. 14.

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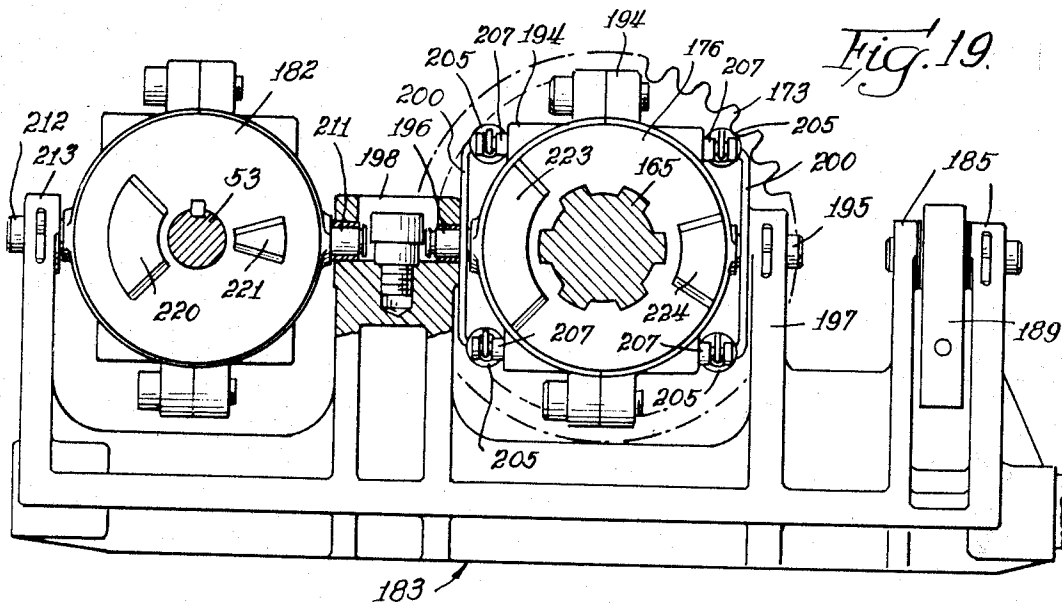
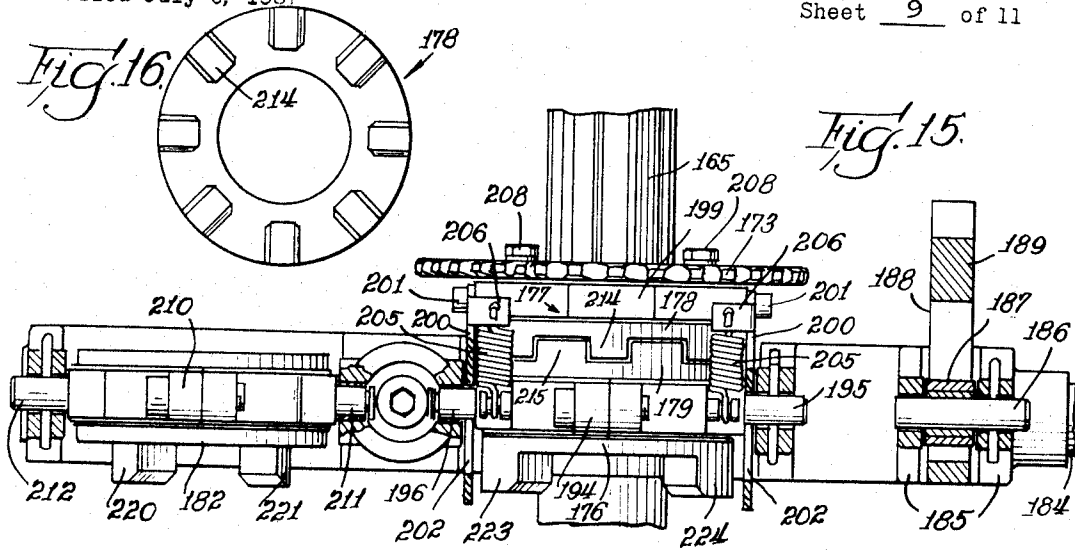
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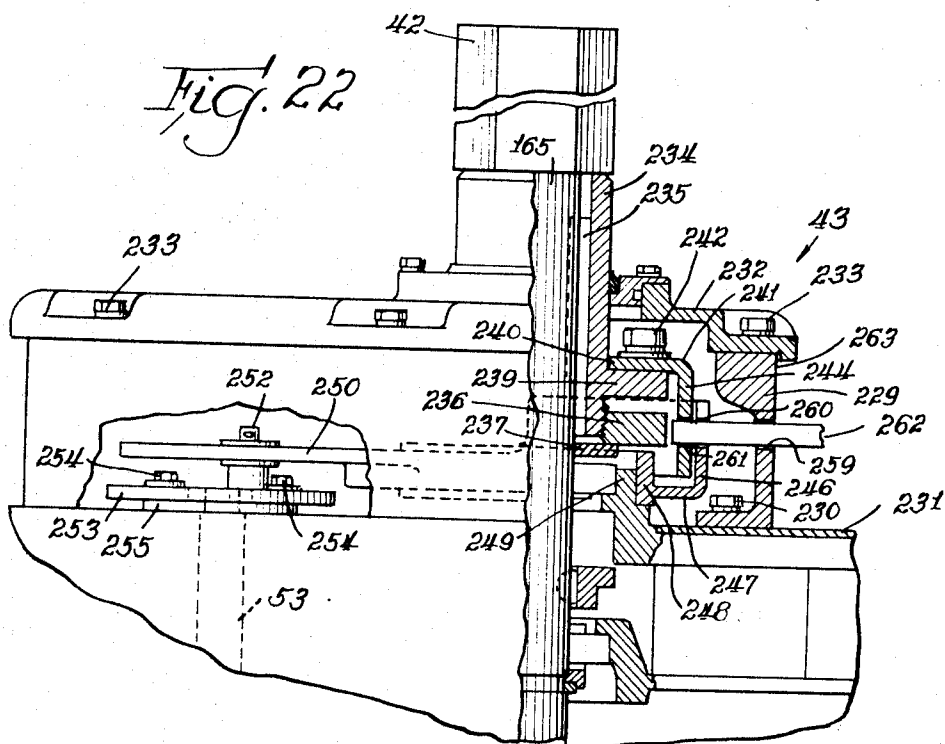
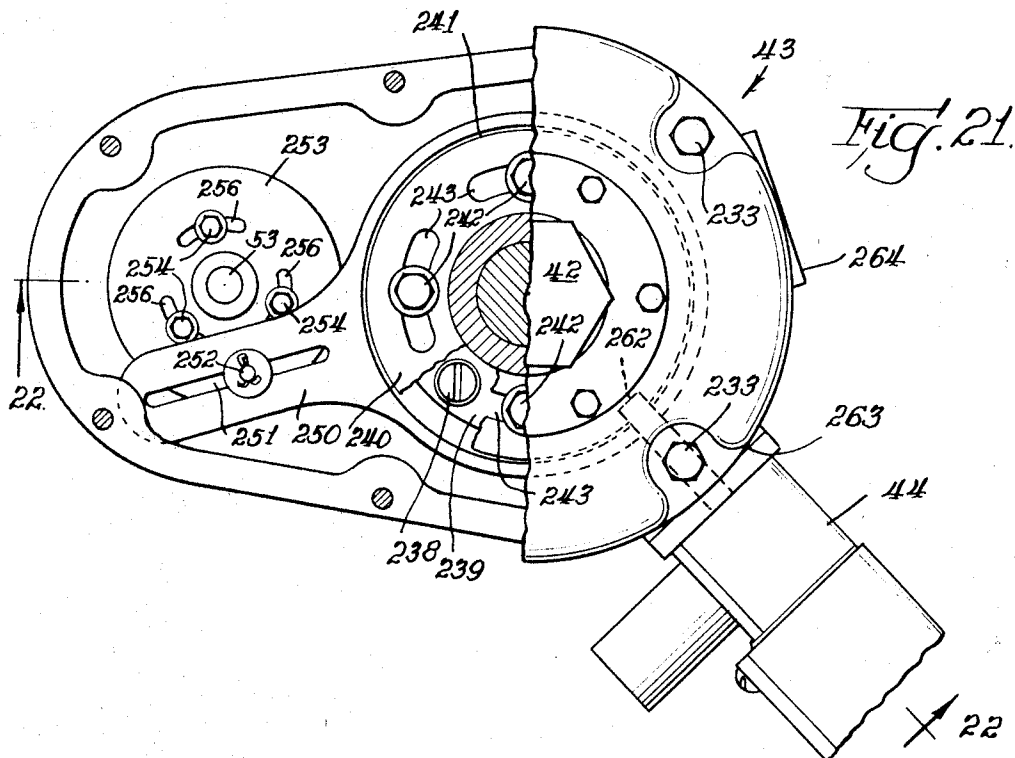
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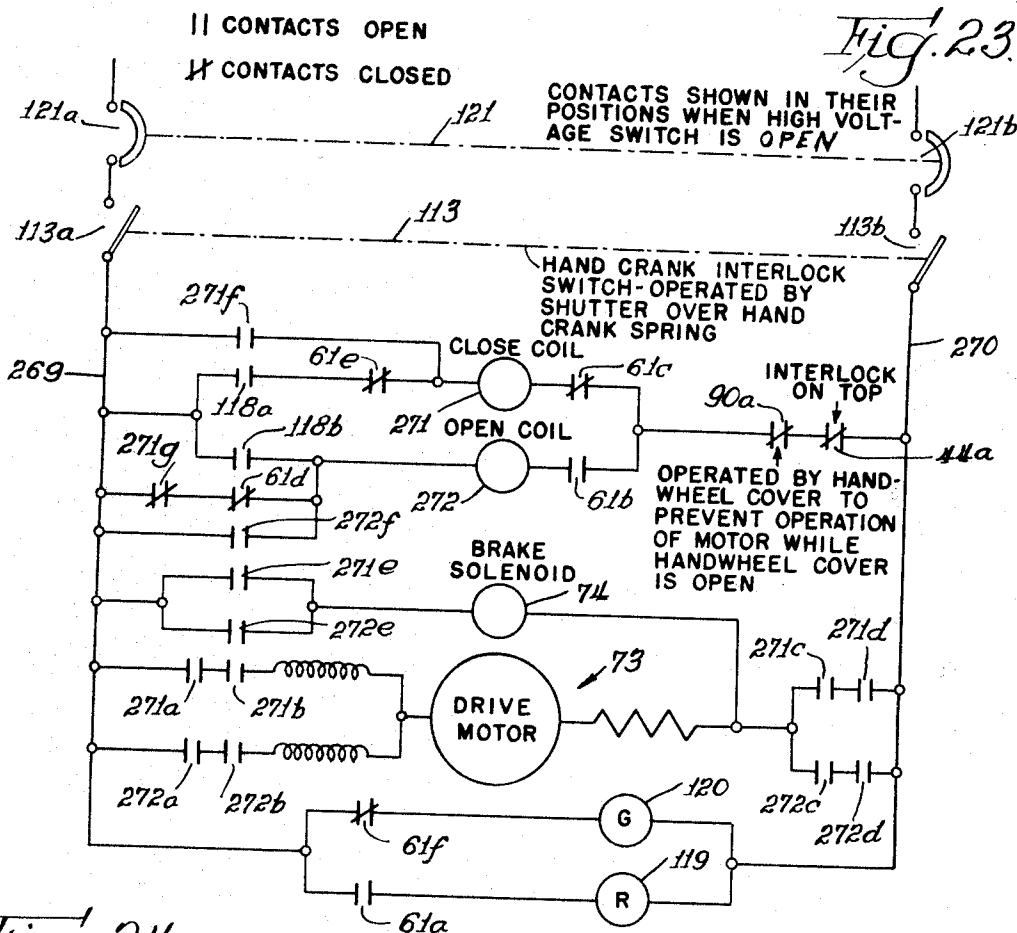


Fig. 24

SWITCH POSITION	OPEN				0	CLOSE				
	1	2	3	4	5	6	7	8	9	
X - CLOSED CONTACT AUXILIARY SWITCH CONTACT								X	X	61a
		X						X	X	61b
	X							X		61c
	X						X			61d
	X	X								61e
	X	X								61f

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3,432,780 MOTOR-DRIVEN OPERATOR FOR HIGH VOLTAGE SWITCH

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28 Claims

ABSTRACT OF THE DISCLOSURE

A motor-driven mechanism utilizing a drive motor, a plurality of shaft means, and a clutch shift means for connecting the shaft means to and from the said drive motor for operating a high voltage switch between open and closed positions at relatively high speed and requiring the application of relatively high torque in a relatively short interval.

This invention relates to operators for high voltage switches such as the switch disclosed in Chabala et al. Patent 3,345,473, issued October 3, 1967. It may be employed for operating other high voltage switches.

Such switches are employed for electric power transmission systems operating at relatively high voltages, such as 230 kv., 345 kv., 500 kv., etc. Accordingly the parts employed are relatively massive and are required to operate at relatively high speed. For illustrative purposes the operator in which the present invention is embodied may be used for simultaneously operating the three poles of a three phase 500 kv. interrupter switch each pole of which employs three rotatable insulator stacks, one being used to operate a pair of series connected interrupter units and the other two carrying at their distal ends center break switch blades each 8' long having contacts and corona shields at their distal ends. For the three poles the rotating parts have a total weight of about 10,000 lbs. which must be accelerated and decelerated through an angle of the order of 102° within an interval of the order of 1½ to 2 seconds. Operation is required under all weather conditions with a temperature range from -40° to 150° F., wind velocity up to 100 m.p.h. and natural ice formation up to 1½" thick. Also manual operation must be provided for.

Accordingly, among the objects of this invention are: To provide for operating a high voltage switch of the kind above referred to under the conditions above outlined; to provide for manually operating the switch; to arrange for a motor to operate a drive shaft having a mechanical driving connection to the three poles of the switch through a plurality of revolutions, for example 3 revolutions, for operating the switch between the open and closed positions while controlling the operation of the motor by a limit switch operated by a control shaft that is driven by the motor to rotate less than one revolution in conjunction with an auxiliary shaft that is driven from the drive shaft to rotate through less than one revolution for the three revolutions of the drive shaft; to selectively clutch and de-clutch the motor and the manual operator to and from the drive shaft and the auxiliary shaft to and from the control shaft and thereby to and from the motor limit switch; to clutch the motor to the drive shaft and the auxiliary shaft to the control shaft in only one angular position of the control shaft with respect to the angular position of the drive shaft in order to maintain proper control of the motor in accordance with the open or closed positions of the high voltage switch; to prevent energization of the drive motor when a hand crank is applied for manual operation of the high voltage switch, when the high voltage switch is locked in a predetermined position, for example in the open position, and when the drive motor is rotated

manually to align the control shaft with the drive shaft to employ a brake in conjunction with the drive motor for arresting rotation thereof and the parts driven thereby when the motor is deenergized; and to release the brake to facilitate declutching of the drive shaft from the drive motor and manual operation of the drive motor.

According to this invention an electric drive motor is mechanically connected by a motor drive clutch to a drive shaft that is mechanically connected to the high voltage switch and is arranged to be rotated through a plurality of revolutions, for example three, in order to develop the necessary torque for operation of the high voltage switch under the conditions above outlined. The deenergization of the motor and the control shaft. The motor drive by a control shaft that is reduction geared directly to an output shaft of the motor to rotate through less than one revolution between the open and closed positions of the high voltage switch. The control shaft is mechanically connected by an auxiliary clutch to an auxiliary shaft that is reduction geared directly to the drive shaft to rotate through less than one revolution while the drive shaft rotates through the plurality of revolutions, the degree of reduction being the same as that between the output shaft of the motor and the control shaft. The motor drive clutch and the auxiliary clutch are so constructed that they are engageable only when the drive shaft is rotated to a predetermined angular position with respect to the angular position to which the control shaft is rotated by the motor. A solenoid control spring operated brake is connected to the drive motor for stopping it promptly on deenergization of the motor. The brake is released when the drive motor is to be manually rotated for clutch alignment purposes and also when the motor drive clutch is declutched and a manual drive clutch is engaged to permit manual rotation of the drive shaft and manual operation of the high voltage switch. Energization of the motor is prevented when a hand crank is used for manual operation of the high voltage switch and when the high voltage switch is locked in a predetermined position, such as the open position. Also energization of the drive motor is prevented when it is manually rotated for the clutch alignment purposes. A mechanical interlock prevents application of the hand crank to the manual operating mechanism unless the motor drive clutch is declutched and the manual drive clutch mechanically connects the drive shaft to the manual drive mechanism.

In the drawings: FIG. 1 is a perspective view of a high voltage switch for use on an alternating current electric power transmission system operating at a voltage of the order of 500 kv. arranged for operation by an operator in which this invention is embodied. FIG. 2 is a view, in front elevation, of the switch operator in which this invention is embodied, the operator being shown in a housing the door of which has been removed. FIG. 3 is a horizontal sectional view at an enlarged scale taken generally along the line 3-3 of FIG. 2. FIG. 4 is a view, in side elevation, of the construction shown in FIG. 2, the selector handle being shown in the manual operating position and a hand crank being shown for manual operation. FIG. 5 is a vertical sectional view of the housing with certain parts of the manual operating mechanism and brake release linkage being shown in elevation, the view being taken looking from right to left of FIG. 2. FIG. 6 is a sectional view of the housing and shows in elevation the arrangement of the clutch housing, the speed reducer, the drive motor and a portion of the brake release linkage in elevation, the view being taken looking from left to right of FIG. 2. FIG. 7 is a view, partly in vertical section and partly in elevation, of a portion of the manual operating mechanism. FIG. 8 is a view, in side elevation, of the manual operating mechanism shown in FIG. 7. FIG. 9 is a view, partly in side elevation and partly in section,

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 taken generally along the line 9—9 of FIG. 8. FIG. 10 is a view, partly in end elevation and partly in section, showing details of construction of a portion of the manual operating mechanism with the levers connected to the brake release linkage and to the handwheel access door being shown schematically. FIG. 11 is a view, partly in elevation and partly in section, looking from right to left of FIG. 10. FIG. 12 is a sectional view, taken along line 12—12, of the lost motion coupling members shown in FIG. 11. FIG. 13 is a view, partly in elevation and partly in section, showing the various clutches that are employed, the illustration showing the clutch positions for manual operation of the high voltage switch. FIG. 14 is a view, in side elevation, of the construction shown in FIG. 13. FIG. 15 is a view, in front elevation, of portions of the clutches shown in FIG. 13, the operating cam and portions of the clutch operating frame being shown in section. FIG. 16 is a bottom plan view of the top part of the manual drive clutch shown in FIG. 15. FIG. 17 is a top plan view of the lower portion of the auxiliary clutch that is arranged to engage the upper portion shown in FIG. 15. FIG. 18 is a top plan view of the lower element of the motor drive clutch for engagement with the upper portion shown in FIG. 15. FIG. 19 is a bottom plan view of the clutch construction shown in FIG. 15. FIG. 20 is a view, in side elevation, of the clutch control cam and a portion of one of the arms of the clutch operating frame. FIG. 21 is a top plan view of the interlock mechanism at the top of the housing for the operator. FIG. 22 is a partial vertical sectional view taken generally along the line 22—22 of FIG. 21, other parts being shown in elevation. FIG. 23 shows diagrammatically the circuit connections employed for controlling the operation of the drive motor. FIG. 24 is a chart showing the different positions of the motor control contacts in the diagram shown in FIG. 23.

FIG. 1 shows, generally at 10, a high voltage switch of the kind and character referred to above. More specifically the switch 10 is a three phase switch for use in conjunction with alternating current power transmission systems operating at a voltage of the order of 500 kv. Typical characteristics of a switch of this kind have been referred to above. The switch 10 comprises three poles 11, 12 and 13 which are identical in construction. Each pole comprises a pair of individual supports 14 adapted to be mounted at their lower ends on the ground or on a suitable support slab mounted on the ground. At their upper ends each pair of supports 14 carries a longitudinally extending base member 15 from which a stationary insulator 16 extends upwardly at one end. Spaced along the base member 15 are rotatable insulators 17, 18 and 19. An interrupter operating mechanism 20 is mounted on the upper end of rotatable insulator 17. Load current interrupters 21 and 22 are mounted between the upper end of the stationary insulator 16 and one side of the interrupter operating mechanism 20 and between the opposite side of the interrupter operating mechanism 20 and the upper end of the rotatable insulator 18. Switch blades 24 and 25 are mounted on the upper ends of the rotatable insulators 18 and 19. Provision is made for conjoint rotation of the insulators 17, 18 and 19 for operating the load current interrupters 21 and 22 and the switch blades 24 and 25 in the manner outlined in the patent above referred to.

For simultaneously operating the three poles 11, 12 and 13 of the high voltage switch 10 interphase shafts 26 and 27 are employed and are suitably connected to linkages in the base member 15 for effecting operation of the individual poles 11, 12 and 13. A spiroid gear assembly 28 is arranged to transmit torque to the interphase shafts 26 and 27 and it is located close to their junction and is arranged to have a gear reduction of the order of 6:1. The spiroid gear assembly 28 is driven by a vertically extending drive shaft 29 that is arranged to rotate through about three revolutions for effecting a complete operation of each of the poles 11, 12 and 13 from the open to the closed position and vice versa. It will be understood that

the drive shaft 29 rotates in one direction through about three revolutions to effect closure of the high voltage switch 10 and that the drive shaft 29 is rotated through about three revolutions in the opposite direction to effect opening of the high voltage switch 10. A mechanism, shown generally at 30, is arranged to rotate the drive shaft 29 for operating the high voltage switch 10. The reason for rotating the drive shaft 29 through a plurality of revolutions while the insulators 17, 18 and 19 are required to rotate through an angle of about 102° between the open and the closed positions is to permit the use of a mechanism 30 in which a drive motor of reasonable size can be employed. However, since the drive shaft 29 is arranged to rotate through more than one revolution for each direction of operation of the high voltage switch 10, certain complications are introduced the solution to which is provided by this invention.

In FIGS. 2 and 4 certain details of the mechanism 30 for operating the high voltage switch 10 are shown. It includes a weatherproof metallic housing 33 having top and bottom walls 34 and 35, left and right side walls 36 and 37, a rear wall 38 and a door 39, which is shown only in FIG. 4. For driving connection to the upwardly extending drive shaft 29, FIG. 1, a hexagonal coupling section 42 is employed at the upper end of the metallic housing 33. The coupling section 42 extends upwardly from an interlock housing that is indicated, generally, at 43 and is mounted on the upper side of the top wall 34. A key operated interlock 44 extends laterally from the interlock housing 43 and it is employed in a manner to be described for locking the drive shaft 29 in a predetermined position. For example, the drive shaft 29 can be locked in a position corresponding to the open position of the high voltage switch 10 with the arrangement being such that the interlock 44 can be unlocked only by a special key and when locked, prevents energization of the operating mechanism within the metallic housing 33.

Inside the metallic housing 33 and near the top there is mounted a clutch housing that is indicated, generally, at 45. A cover 46 closes the front side of the clutch housing 45. Viewing openings 47 and 48 are provided in the cover 46 to permit observation of indexes 49 and 50 that are carried, respectively, by a switch position indicator disc 51 and a motor position indicator disc 52. The switch position indicator disc 51 is mounted on an auxiliary shaft 53 which extends vertically and is geared to the drive shaft 29 and to the hexagonal coupling section 42 for rotation therewith. A control shaft 54 is rotatably mounted on the lower end of the auxiliary shaft 53 and it is arranged to carry the motor position indicator disc 52. The control shaft 54 is geared to the motor to rotate therewith.

Mounted on the left side wall 36 is auxiliary switch means 57 which includes a number of contacts that are arranged to be closed and opened in accordance with the positions of the movable parts of the poles 11, 12 and 13 of the high voltage switch 10. For operating the auxiliary switch means 57 a sprocket 58 is employed at its upper end which is driven by a chain 59 from a sprocket 60 that is mounted on the lower end of the auxiliary shaft 53 and thus rotates therewith. In this manner the operation of the auxiliary switch means 57 reflects the operation of the high voltage switch 10.

Also mounted on the left wall 36 of the metallic housing 33 is limit switch means 61. It is arranged, in part, to control the operation of a drive motor to be described. For operating the limit switch means 61 an operating arm is employed and it is connected by an adjustable link 63, FIG. 3, to an arm 64 of a pivotally mounted cam follower 65. The cam follower 65 has integrally formed arms 66 and 66' carrying rollers 67 and 67' at their distal ends for operation by cams that are adjustably mounted on the control shaft 54.

In FIG. 2 the cover 46 for the clutch housing 45 is provided with another viewing opening 68 for inspection of a motor drive clutch that is indicated, generally, at 69.

The motor drive clutch 69 is arranged to be operated by a motor clutch drive member 71 which extends upwardly from and is driven through a speed reducer, indicated generally at 72, by a drive motor that is indicated, generally, at 73. Spring biased solenoid operated brake means, shown generally at 74, cooperate with the drive motor 73 for promptly arresting rotation thereof and parts driven thereby on deenergization of the drive motor 73. The speed reducer 72, drive motor 73 and brake means 74 are of conventional construction and will not be described in detail herein. The speed of rotation of the drive motor 73 is reduced by the speed reducer 72 to drive the motor clutch drive member 71 and conjointly therewith the motor drive clutch 69, the coupling section 42 and the drive shaft 29. The reason for employing the speed reducer 72 is to permit the use of a relatively small, high speed drive motor 73 which can be accommodated readily within the confines of a relatively small metallic housing 33. From a mechanical standpoint the motor clutch drive member 71, although it is driven through the speed reducer 72, can be considered as being connected to the drive motor 73 directly without requiring the interposition of the speed reducer 72.

Under certain operating conditions, to be described, it is desirable to release the brake means 74. For this purpose a brake release plunger 75 is employed. It is operated, in part, under the control of the solenoid which forms a part of the brake means 54 for releasing it on energization of the drive motor 73. The brake release plunger 75 is biased upwardly by a spring 76 and is arranged to be moved downwardly, either by the solenoid or by externally operable means. For this purpose a transverse pin 77 extends through the lower end of the brake release plunger 75 for engagement by ends 78 of a pair of brake release levers 79 which are pivoted at 80 and are connected at their opposite ends 81 to the lower end of a brake release rod 82 which extends upwardly and is connected at its upper end to a lever 83 which is carried by a transverse shaft 84 that is pivotally mounted in a bracket 85.

Under certain conditions, to be described, it is desirable to rotate manually the drive motor 73. For this purpose a handwheel 86 is employed and is connected directly to the drive motor 73. However, it is desirable that access to the handwheel 86 be prevented except under conditions where the safety of the operator is assured. For this purpose an access cover 87 normally overlies the handwheel 86. The access cover 87 is pivotally mounted at 88 and a spring 89 serves to bias it to the position where it overlies the handwheel 86 as shown in FIG. 2. In a manner to be described the access cover 87, when opened, is arranged to move the brake release rod 82 downwardly to release the brake means 74. In addition a cover interlock switch 90 is provided and is arranged to be operated when the access cover 87 is opened for the purpose of opening a set of contacts which prevent energization of the drive motor 73.

For installation and adjustment and testing purposes it is desirable to permit manual operation of the high voltage switch 10. It is for this purpose that the motor drive clutch 69 is provided to permit disconnection of the drive motor 72 from the drive shaft 29. For manual operation manually operable drive means, shown generally at 91, in FIG. 2, is employed. The manually operable drive means 91 includes a vertical drive shaft 92 having a sprocket 93 at the upper end. Provision is made for connecting the sprocket 93 to rotate the drive shaft 29 in a manner to be described. At its lower end the drive shaft 92 is connected by a worm gear assembly, shown generally at 94, to a transverse drive shaft 95 to which a hand crank 96, FIG. 4, can be detachably connected.

For shifting the drive for the drive shaft 29 from the drive motor 73 to the manually operable drive means 91, clutch shift means, shown generally at 99, FIG. 2, is employed. The clutch shift means 99 includes a transverse

shaft 100 that is suitably pivotally mounted on the clutch housing 45. An arm 101 is secured to the outstanding end of the shaft 100 and to it is connected a gear shift rod 102 at its upper end. The lower end of the gear shift rod 102 is connected to an arm 103 which extends from and rotates with a drum portion 104 of a selector handle 105 which is pivotally mounted on the transverse drive shaft 95 so as to have its axis of rotation coincident with the axis of rotation of the shaft 95. The drum portion 104 to which a selector handle 105 is secured includes a hand crank receiving means 106 into which the hand crank 96 can be inserted. In order to prevent insertion of the hand crank 96, except under certain conditions, a shutter 107 overlies the hand crank receiving means 106 and must be pivotally moved out of this overlying position. The shutter 107 is mounted on a transverse shaft 108 which is pivoted on the right side wall 37 of the metallic housing 33 and extends therethrough. A flange 109, integral with the shutter 107, facilitates manual pivoting thereof with the shaft 108. A locking pin 110 is carried by the selector handle 105 and must be withdrawn before the selector handle 105 can be swung to the position shown in FIG. 4.

When the hand crank 96 is inserted for manual operation, it is desirable that provision be made for preventing energization of the drive motor 73. For this purpose a hand crank interlock switch 113, FIG. 2, is mounted on the right side wall 37 of the metallic housing 33. The hand crank interlock switch 113 has an upwardly extending operating shaft 114 to which an arm 115 is secured. The arm 115 is connected by a link 116 to an arm 117 which is secured to the shaft 108 to which the shutter 107 also is secured. When the shutter 107 is moved to the position shown in FIG. 4 to permit insertion of the hand crank 96, the hand crank interlock switch 113 is opened to prevent energization of the drive motor 73.

For initiating the energization of the drive motor 73 for either closing or opening the high voltage switch 10, a manually operable control switch 118, FIG. 2, is mounted adjacent the right side wall 37 and inside the metallic housing 33. Red and green indicating lamps 119 and 120 are provided for visually indicating the position of the high voltage switch 10. A control circuit breaker 121 is mounted on the inside of the side wall 37 near the bottom of the metallic housing 33 for controlling the energization of all of the control circuits associated with the drive motor 73 and the high voltage switch 10.

FIGS. 5-12 show certain details of the manually operable drive means 91 and the clutch shift means 99. A support bracket 124, FIG. 10, has the lower end of the drive shaft 92 journaled therein. A worm wheel 125 is secured to the lower end of the drive shaft 92 and it is arranged to be rotated by a worm 126, FIG. 7, which is mounted on and rotates with the transverse drive shaft 95 which is arranged to be rotated manually by the hand crank 96. The drum portion 104 of the selector handle 105 through which the transverse drive shaft 95 extends, FIG. 7, is journaled in a bearing ring 127 which is secured by bolts 128 that extend through the right side wall 37 and into a selector handle mount 129 which is positioned on the outside of the right side wall 37. The hand crank receiving means 106, which is integral with the drum portion 104, is mounted within the selector handle mount 129. A transverse key 130 extends across the outer end of the transverse drive shaft 95 for receiving the hand crank 96. The locking pin 110 is biased by a compression spring 131 toward a base portion 132 of the selector handle mount 129. A pair of openings (not shown) are provided in the base portion 132 for receiving locking end 133 of the locking pin 110 in either of two operating positions of the selector handle 105.

Movement of the shutter 107, FIG. 8, from overlying position with respect to the hand crank receiving means 106 is prevented unless the selector handle 105 is moved from the position shown here to the alternate position shown in FIG. 4 in which the motor drive clutch 69 is

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 declutched from the drive motor 73 and manual operation of the high voltage switch 10 is permitted. For preventing movement of the shutter 107 to uncover the hand crank receiving means 106, shoulders 135 and 136 are formed integrally with the shutter 107 and are arranged to be spaced slightly from a flange 137 on the hand crank receiving means 106. Movement of the shutter 107 is permitted when the selector handle 105 is swung to the manual position which brings a notch 138 in the hand crank receiving means 106 into registry with the shoulder 136. In this position the shutter 137 can be swung together with the shaft 108 and parts connected thereto to the position where the hand crank receiving means 106 is uncovered and insertion of the hand crank 96 is permitted.

When the access cover 87 is opened to permit access to the handwheel 86, the brake 74 must be released to permit manual rotation of the drive motor 73. It is for this purpose that the brake release rod 82 is connected to the lever 83 which is secured to the shaft 84. FIGS. 10 and 11 show further details. Here a link 139 is connected at one end to an arm 140 which is secured to the shaft 84 while its other end is connected by a pin 141 to the access cover 87. When the access cover 87 is swung to the open position, through the link 139 and arm 140, the shaft 84 is pivoted to move the lever 83 and thereby the link 82 to release the brake means 74. A torsion spring 142 acts to bias the access cover 87 to the closed position overlying the handle 86 and carries with it the parts linked directly thereto.

Also the brake means 74 should be released when the selector handle 105 is moved to operate the clutch shift means 99 and disconnect the direct drive to the drive motor 73 by declutching the motor drive clutch 69. Accordingly additional means are provided for pivoting the shaft 84 to effect release of the brake means 74. The means include a shaft 144 which is positioned, FIG. 11, endwise of shaft 84 and is arranged to be connected thereto by a lost motion coupling that is indicated, generally, at 145. The coupling 145 includes coupling members 146 and 147, one of which is shown in end elevation in FIG. 12. The coupling members 146 and 147 are identical and have outwardly extending diametrically located bosses 148. The bosses 148 permit limited pivoting of the shaft 84 independently of the shaft 144. Thus the access cover 87 can be opened to release the brake means 74 without effecting movement of the shaft 144 and parts connected directly thereto. The shaft 144 has a sector shaped lever 149 secured to it. The sector shaped lever 149, FIG. 10, has an arcuate slot 150 which terminates in a notch 151. A pin 152, FIG. 5, at one end of a link 153 which is connected at its other end to the arm 103, is arranged to drive the sector shaped lever 149 through a predetermined angle and pivot shaft 144 sufficiently far to pivot shaft 84 and release the brake means 74. Thereafter, the pin 152 slips out of engagement with the notch 151 and continued pivoting of the arm 103 conjointly with further pivoting of the selector handle 105 is permitted. An adjustable stop 154, FIG. 10, limits pivoting movement of the sector shaped lever 149 in a reverse direction.

FIGS. 13-14 show in more detail the mechanism inside the clutch housing 45. The clutches here are shown in the manual drive position in which the drive motor 73 and speed reducer 72 are uncoupled from the drive shaft 29. The cam follower 65 is employed for operating the limit switch means 61 to control the deenergization of the drive motor 73. It will be noted that the cam follower 65 is pivoted on a shaft 158 that depends from the clutch housing 45. The rollers 67 and 67' carried by the cam follower 65 are arranged to be engaged by switch open and closed cams 159 and 159' respectively for controlling the operation of the limit switch means 61. Provision is made for adjusting the positions of the cams 159 and 159' on the control shaft 54 in order to provide for accurately adjusting the operation of the limit switch means 61. In order to drive the control shaft 54 in accordance with the position of the motor clutch drive member 71, which corresponds to the position of the drive motor 73 as reflected

by the speed reducer 72, a reduction gear train, shown generally at 160, is employed. The reduction gear train 160 includes a gear 161 that is secured to the motor clutch drive member 71. The gear 161 meshes with a gear 162 that is suitably rotatably mounted in the clutch housing 45 and has for rotation therewith a pinion 163 which meshes with a gear 164 that is secured to and rotates with the control shaft 54.

It will be recalled that the drive shaft 29 is connected to the hexagonal coupling section 42, FIG. 2, and thus forms a part thereof. The hexagonal coupling section 42 is secured to and rotates with a drive shaft extension 165 which is suitably rotatably mounted in the upper end of the clutch housing 45. Thus the drive shaft 29, hexagonal coupling section 42 and drive shaft extension 165 in effect constitute a single driving member for operating the high voltage switch 10. In order to interconnect the drive shaft extension 165 and the auxiliary shaft 53, a reduction gear train, shown generally at 166, is employed and it has the same reduction as the reduction gear train 160. The reduction gear train 166 includes a gear 167 that is mounted on the drive shaft extension 165 and rotates therewith. The gear 167 meshes with a gear 168 that is suitably rotatably mounted in the clutch housing 45 and has for rotation therewith a pinion 169 which engages a gear 170 that is keyed to the auxiliary shaft 53 and thus rotates therewith.

For manually rotating the drive shaft extension 165 to effect the manual operation of the high voltage switch 10, a sprocket 173 is arranged to be connected to the drive shaft extension 165 and is connected by a chain 174 to the sprocket 93 which is located on the upper end of the vertical drive shaft 92 which is rotated through the spiroid gear assembly 94 by the shaft 95 when the hand crank 96 is connected thereto.

The motor drive clutch 69 is employed for interconnecting the motor clutch drive member 71 and the drive shaft extension 165. The motor drive clutch 69 includes a motor clutch drive member 175 that is secured to and rotates with the motor clutch drive member 71. The motor drive clutch 69 also includes a cooperating motor clutch driven member 176 that is splined to the lower end of the drive shaft extension 165 and thus is slidably and non-rotatably mounted thereon.

A manual drive clutch, shown generally at 177, is employed for interconnecting the sprocket 173 and the drive shaft extension 165 to permit manual rotation of the drive shaft extension 165 and manual operation of the high voltage switch 10. The manual drive clutch 177 includes a manual clutch drive member 178 that is secured to the sprocket 173 and both are arranged to rotate freely on the lower end of the drive shaft extension 165. The manual drive clutch also includes a manual clutch driven member 179 that is splined to the lower end of the drive shaft extension 165 and is secured to and is movable with the motor clutch driven member 176.

Since the drive shaft extension 165 rotates through a plurality of revolutions, for example three, in operating the high voltage switch 10 from the open position to the closed position and from the closed position to the open position, it is necessary to provide for insuring that engagement of the motor clutch drive and driven members 175 and 176 takes place only in the axial position of the drive shaft extension 165 corresponding to an axial position of the auxiliary shaft 53 in order to obtain proper operation of the limit switch means 61 for controlling the deenergization of the drive motor 73 so that this is effected only at the ends of the stroke of the high voltage switch 10, i.e., only when the switch blades 24 and 25 occupy either the full open position, as shown in FIG. 1, or are in their fully closed position. For this purpose an auxiliary clutch shown generally at 180 is employed for interconnecting the auxiliary shaft 53 and the control shaft 54. The auxiliary clutch 180 includes a first auxiliary clutch member 181 that is secured to and rotates

with the control shaft 54. The auxiliary clutch 180 also includes a second auxiliary clutch member 182 which is splined onto the lower end of the auxiliary shaft 53 and thus is slidably and non-rotatably mounted thereon.

It will be recalled that selector handle 105 is connected by the clutch shift means 99 including the gear shift rod 102, FIG. 2, to rock transverse shaft 100 for shifting the clutches. The manner in which this is effected is illustrated more clearly in FIG. 13. For this purpose a clutch shift member, shown generally at 183, is employed. It is provided at its ends with trunnions 184 that are journaled in the side walls of the clutch housing 45. A pair of arms 185 extend from the clutch shift member 183 and carry at their distal ends a pin 186 on which a roller 187, FIG. 14, is mounted. The roller 187 is located in an arcuate slot 188 that is formed in a cam 189 which is secured to the transverse shaft 100 and rotates therewith. On rotation of shaft 100 in a counterclockwise direction, as viewed in FIG. 14, the cam 189, acting through the roller 187 and clutch shift member 183, is effective to declutch the manual drive clutch 177 and to cause the motor drive clutch 69 and the auxiliary clutch 180 to engage, provided that these clutches are located in such relative position that this engagement is permitted.

FIGS. 15-20 show in more detail the construction of the motor drive clutch 69, the manual drive clutch 177 and the auxiliary clutch 180 and the manner in which they are operated between the clutched and declutched positions. FIG. 20 shows the position of the arms 185 on the clutch shift member 183 and of the cam 189 when the selector handle 105 occupies its position as shown in FIG. 8 in which the motor 73 is connected through the motor drive clutch 69 to the drive shaft extension 165, the auxiliary shaft 53 is connected to the control shaft 54 and the manual drive clutch 177 is declutched.

Referring in particular to FIGS. 15 and 19, a clamp assembly 194 is shown for rotatably mounting the motor clutch driven member 176 and the manual clutch driven member 179 which are splined to the lower end of the drive shaft extension 165. Trunnions 195 and 196 extend in opposite directions from the clamp assembly 194 with the trunnion 195 being pivoted in an arm 197 extending from the clutch shift member 183 and the trunnion 196 being pivoted in one side of an arm 198 that also extends from the clutch shift member 183. For mounting the sprocket 173 and manual clutch drive member 178 for rotation with respect to the drive shaft extension 165 a collar 199 is positioned therebetween and is stationarily mounted by side plates 200 which are secured thereto by socket head cap screws 201. Slots 202 are formed in the side plates 200 to receive the trunnions 195 and 196 therethrough. The lower ends of the side plates 200 are supported by a bracket 203, FIG. 13, in the clutch housing 45 and by a collar 204 that is secured to the inner end of the shaft 100. The collar 199 and thereby the sprocket 173 and the manual clutch drive member 178 are biased downwardly by coil tension springs 205 which are fastened at their upper ends to ears 206 that extend laterally from opposite sides of the side plates 200. At their lower ends the coil tension springs 205 are connected to pins 207 that extend laterally from opposite sides of the clamp assembly 194. Bolts 208 extend through the sprocket 173 and into the manual clutch drive member 178 to provide for conjoint rotation thereof.

For movably mounting the second auxiliary clutch member 182 on the auxiliary shaft 53 a clamp assembly 210 is employed. It has oppositely extending trunnions 211 and 212, with the former being pivoted in the side of arm 198 opposite that in which the trunnion 196 is pivoted while the latter is pivoted on an arm 213 which extends from the clutch shift member 183.

When the clutch shift member 183 is operated to declutch the motor drive clutch 69 and engage the manual

drive clutch 177, there is the possibility that the teeth 214 on the manual clutch drive member 178 may not be so aligned with the teeth 215 on the manual clutch driven member 179 as to permit engagement. When this occurs, the coil tension springs 205 are extended and the clamp assembly 194 together with the sprocket 173 and manual clutch drive member 178 are moved upwardly. On rotation of the sprocket 173 by the hand crank 96, the manual clutch drive member 178 is rotated to a position where the teeth 214 and 215 engage whereupon the springs 205 move them into meshing engagement.

FIG. 16 shows a bottom plan view of the manual clutch drive member 178 which is secured by the bolts 208 to the sprocket 173. The teeth 214 on the manual clutch drive member 178 are arranged to engage between sector shaped teeth 215 on the manual clutch driven member 179.

FIG. 17 is a top plan view of the first auxiliary clutch member 181 that is secured to the control shaft 54. It carries flat topped teeth 219 which are two in number and of equal arcuate length and unsymmetrically spaced. The teeth 219 are arranged to cooperate with flat topped teeth 220 and 221, FIG. 19, which extend downwardly from the underside of the second auxiliary clutch member 182. The tooth 220 has a substantially greater arcuate length than does the tooth 221. The reason for this is to prevent the second auxiliary clutch member 182 from moving downwardly to permit engagement of the motor drive clutch 69 and the auxiliary clutch 180 are in the predetermined relative positions in order to maintain synchronization between the operation of the limit switch means 61 and of the high voltage switch 10. However, there is relatively great clearance between the teeth 219 on the first auxiliary clutch member 181 and the teeth 220 and 221 on the second auxiliary clutch member 182 in order to limit the function of the auxiliary clutch 180 solely to the synchronizing relationship since it is undesirable that there be any direct drive between the auxiliary shaft 52 and the control shaft 54 through the auxiliary clutch 180.

FIG. 18 is a top plan view of the motor drive clutch member 175 which is connected to the motor clutch drive member 171 and thus is driven directly from the drive motor 73 through the speed reducer 72. Teeth 222 extend upwardly from the motor clutch drive member 175 and are of equal arcuate length but are unsymmetrically spaced. They have flat tops and are arranged to have driving engagement between teeth 223 and 224, FIG. 19, which project downwardly from the underside of the motor clutch driven member 176. The tooth 223 has a substantially greater arcuate length than does the tooth 224 for the purpose of providing the synchronization above referred to. There is relatively little clearance between the teeth 222 on the motor clutch drive member 175 and the teeth 223 and 224 on the motor clutch driven member 176 in order to insure that the drive to the drive shaft extension 165 and thereby to the high voltage switch 10 from the motor 53 is effective only through the motor drive clutch 69.

FIGS. 21 and 22 show the details of construction for using the key operated interlock 44 to lock the high voltage switch 10 in a given position, for example in the open position shown in FIG. 1. Here it will be observed that the hexagonal coupling section 42, which is connected to the drive shaft 29, is formed integrally with the upper end of the drive shaft extension 165 which projects downwardly through the interlock housing 43. The interlock housing 43 includes a casing 229 that is secured by bolts, one of which is indicated at 230, to the upper wall 231 of the clutch housing 45. A cover 232 overlies the upper end of the casing 229 and is secured thereto by bolts 233. Just below the hexagonal coupling section 42 an interlock collar 234 is mounted and is secured against rotation to the drive shaft extension 165 by a key 235.

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At its lower end the interlock collar 234 has an adjusting plate nut 236 threaded thereon for reacting against a washer 237 to properly position the drive shaft extension 165 and to take the play out of the bearings by means of which it is mounted in the upper wall 231 of the clutch housing 45. The adjusting plate 236 is secured against rotation by screws one of which is indicated at 238, FIG. 21, to a flange 239 which extends radially from the interlock collar 234.

In order to provide the interlocking action using the key operated interlock 44, a bottom wall 240 of an inverted pan-shaped interlock stop 241 overlies the flange 239 and is secured thereto by bolts 242. As shown in FIG. 21 the bolts 242 extend through arcuate slots 243 in the bottom wall 240 to permit adjustment thereof with respect to the flange 239. A depending flange 244 of the interlock stop 241 is telescoped within an upstanding flange 246 of an interlock shutter 247 which is generally pan-shaped and has a central upstanding bearing flange 248 that is journaled on an upstanding bearing flange 249 that is formed integrally with the upper wall 231 of the clutch housing 45. An arm 250 extends radially from the interlock shutter 247 and has a longitudinal slot 251, FIG. 21, for receiving a pin 252 that projects upwardly from a plate 253. The plate 253 is secured by bolts 254 to a flange 255, FIG. 22, which is welded to the upper end of the auxiliary shaft 53. Arcuate slots 256 in the plate 253 permit relative adjustment of it with respect to the flange 255.

It will be recalled that the hexagonal coupling section 42 and the drive shaft extension 165 rotate through approximately three revolutions between the open and closed positions of the high voltage switch 10. The reduction gear train 166 is arranged to rotate the auxiliary shaft 53 through approximately 180° when the drive shaft extension 165 is rotated through three revolutions. Accordingly, the auxiliary shaft 53 does not rotate through more than one revolution and in the specific embodiment disclosed herein it rotates through about 180° or one-half a revolution. When the drive shaft extension 165 is in a position corresponding to the open position of the high voltage switch 10, as shown in FIG. 1, the interlock stop 241 occupies the position shown in FIGS. 21 and 22. At the same time the auxiliary shaft 53 and the plate 253 rotatable therewith occupy the position shown in these figures. This assumes that the motor drive clutch and the auxiliary clutch 180 are in the clutched position. Also this assumes that the limit switch means 61 occupies the position corresponding to the open position of the high voltage switch 10. An opening 259 in the casing 229 is aligned with key openings 260 and 261 in the upstanding flange 246 of the interlock shutter 247 and in the depending flange 244 of the interlock stop 241 respectively by adjusting their positions on loosening bolts 242 and 254. After alignment of these openings, these bolts are tightened. With these openings 259, 260 and 261 thus aligned, it is possible to insert an interlock bolt 262 which forms a part of the key operated interlock 44. The interlock bolt 262 effectively prevents rotation of the drive shaft extension 165 and of the drive shaft 29 to the high voltage switch 10. This arrangement is used for safety purposes when it is desired to make certain that the high voltage switch 10 cannot be inadvertently closed.

The key operated interlock 44 is of conventional construction and is arranged to receive a key for operating the interlock bolt 262 into the locked position shown in FIG. 22. Under these conditions the key normally cannot be removed. Also, as will appear hereinafter, contacts are arranged to be operated when the interlock bolt 262 is in the locked position for the purpose of preventing energization of the control system within the housing 33.

As shown in FIG. 21, the key operated interlock 44 is mounted on a flat portion 263 of the casing 229. If desired, another key interlock can be positioned on another flat portion 264 of the casing 229 with the arrange-

ment being such that the high voltage switch 10 is thereby locked in the closed position. This requires the drilling of additional registering openings in the flanges 244 and 246 as will be understood readily.

FIG. 23 shows diagrammatically the circuit connections employed for controlling the operation of the drive motor 73 and the brake 74 while FIG. 24 is a chart which shows the positions of certain of the contacts of the limit switch means 61. In FIG. 23 conductors 269 and 270 are energized from a suitable source of direct current having a voltage of the order of 125 volts. With appropriate changes, other voltages can be employed. The conductors 269 and 270 are energized when contacts 121a and 121b of the control circuit breaker 121 are closed. Also they are energized when contacts 113a and 113b of the hand crank interlock switch 113 are closed. It will be recalled that this is the case when the hand crank 96 is removed and the shutter 107 overlies the hand crank receiving means 106. In describing the operation of the system shown in FIG. 23, it will be assumed further that contacts 44a of the key operated interlock 44 are closed which corresponds to the withdrawal of the bolt 262, FIG. 22. Also, since it is assumed that access cover 87 is closed, contacts 90a of the cover interlock switch 90 are closed. As shown in the chart, FIG. 24, contacts 61a and 61b of the limit switch means 61 are open with the high voltage switch 10 in the open position while contacts 61c, 61d, 61e and 61f of the limit switch means 61 are closed. Since contacts 61f are closed, green indicating lamp 120 is lighted.

In order to close the high voltage switch 10 electrically with the selector handle 105 in the coupled position with the motor drive clutch 69 and the auxiliary clutch 180 clutched, the control switch 118, FIG. 2, is operated and contacts 118a thereof are closed. A circuit then is completed for energizing closing coil 271 which can be traced from energized conductor 269 through contacts 118a, 61e, closing coil 271, and contacts 61c, 90a and 44a to energized conductor 270. The motor 73 then is connected for energization between energized conductors 269 and 270 through contacts 271a, 271b, 271c and 271d. Also, the solenoid of brake 74 is energized and it is released by closure of contacts 271e. At contacts 271f a holding circuit is completed for the closing coil 271 and the control switch 118 can be released and contacts 118a thereof opened. Contacts 271g are opened. The drive motor 73 then operates in the manner described to rotate the drive shaft 29 and close the high voltage switch 10. The various positions between open and closed are indicated in a chart, FIG. 24. In the number 2 position contacts 61b are closed to prepare a circuit for subsequently energizing open coil 272. Contacts 61c-d-e-f continue to be closed. At position 3 contacts 61e are opened to open the previously traced circuit in series with contacts 118a and contacts 61f are opened to extinguish the green indicating lamp 120. This condition exists through positions 4, 5 and 6. In the position 7 contacts 61d are opened. In position 8 contacts 61a are closed and the red indicating lamp 119 is lighted. Contacts 61c are opened and the closing coil 271 is deenergized and the contacts previously closed thereby are opened and contacts 271g are closed. In position 9 contacts 61a and 61b only are closed. Contacts 271a-b-c-d-e and f are opened and contacts 271g are closed. Drive motor 73 and brake solenoid 75 are deenergized. The spring 76 resets the brake and rotation of the drive motor 73 and parts driven thereby stops.

During the closing operation of the high voltage switch 10 the auxiliary switch means 57, FIG. 2, are operated since auxiliary shaft 53 is rotated in synchronism with the operation of the high voltage switch 10. Various circuits are opened and closed by the auxiliary switch means 57 as may be desired for indicating various phases of the operation of the high voltage switch 10.

For opening the high voltage 10, contacts 118b of the control switch 118 are closed and an energizing circuit

for the open coil 272 is completed from energized conductor 269 through contacts 118b, open coil 272 and contacts 61b, 90a and 44a to conductor 270. As the result of energization of the open coil 272, the motor 73 is connected to rotate in a reverse direction by closure of contacts 272a, 272b, 272c and 272d to energize it from the conductors 269 and 270. Also contacts 272e are closed to release the brake 74. Contacts 272f are closed to provide a holding circuit around control switch contacts 118b and the open coil 272 remains energized. The chart in FIG. 24 shows the operation of the several contacts of the limit switch means 61 as the high voltage switch 10 moves through the various positions from 9 to 1 and from the closed to the open switch position. Since this sequence of operations is obvious from the foregoing description, it will not be set forth in detail.

For manual operation of the three phase high voltage switch 10 from the open position shown in FIG. 1 the locking pin 110 is withdrawn, the selector handle 105 is rotated to the position shown in FIG. 4 and the brake means 74 is released. The motor drive clutch 69 and auxiliary clutch 180 are unclutched. Manual drive clutch 177 is engaged as illustrated in FIG. 13. The shutter 107 is swung aside and hand crank 96 is inserted in the hand crank receiving means 106 to rotate shaft 95 and thereby drive shaft 29 in the manner described. Through the reduction gear train 166 auxiliary shaft 53 is rotated together with switch position indicator disc 51 and index 49. Motor clutch driven member 176 and the second auxiliary clutch member 182 are also manually rotated. However, the control shaft, motor position indicator disc 52 and disc 50 carried thereby remain stationary as do the motor clutch drive member 174 and the first auxiliary clutch member 181 which is secured to the control shaft 54. By means of the hand crank 96, the switch 10 is closed and opened as described. Before the drive from the motor 73 can be reestablished, the motor drive clutch 69 and auxiliary clutch 180 must be reengaged. This can take place only in one position and when the indexes 49 and 50 are in alignment. With the switch in the full open position to which it has been manually operated there may be some misalignment of the engageable members of the clutches 69 and 180. This is reflected in misalignment of the indexes 49 and 50. For restoring the necessary alignment, the access cover 87 is opened and, by means of the handwheel 86, the motor 73 is rotated in a direction to realign the indexes 49 and 50. The clutches 69 and 180 then can be reclutched on return of the selector handle 105 to the position shown in FIG. 8.

What is claimed as new is:

1. Mechanism for operating a high voltage switch between open and closed positions at relatively high speed and requiring the application of relatively high torque in a relatively short interval comprising

a drive shaft for connection to said switch and rotatable through a plurality of rotations in opposite directions to effect opening or closing thereof,

an auxiliary shaft rotatable through less than one revolution,

a reduction drive connection between said drive shaft and said auxiliary shaft,

a control shaft rotatable through less than one revolution,

a drive motor,

a reduction drive connection between said motor and said control shaft,

a motor drive clutch for connecting said drive shaft to said motor,

an auxiliary clutch between said auxiliary shaft and said control shaft and engageable only when said drive shaft is rotated to a predetermined angular position with respect to the angular position in which said control shaft is rotated by said motor,

manually operable drive means,

a manual drive clutch for connecting said drive shaft to said manually operable drive means, and clutch shift means for clutching and declutching said motor drive and auxiliary clutches and declutching and clutching respectively said manual drive clutch.

2. Switch operating mechanism according to claim 1 wherein

said drive motor is connectable to an electric current source, and

limit switch means operated by said control shaft controls the deenergization of said drive motor at the ends of the opening and closing strokes of said high voltage switch.

3. Switch operating mechanism according to claim 1 wherein auxiliary switch means is operated by said auxiliary shaft in accordance with the position of said high voltage switch.

4. Switch operating mechanism according to claim 1 wherein

brake means is connected to said drive motor for stopping it on deenergization thereof, and

means is connected to said brake means for releasing the same when said drive motor is energized.

5. Switch operating mechanism according to claim 4 wherein means interconnect said clutch shift means and said brake means to release said brake means when said clutch shift means declutches said motor drive clutch.

6. Switch operating mechanism according to claim 4 wherein

a handwheel is connected to said drive motor for manually rotating it,

an access cover overlies said handwheel, and

means interconnect said access cover and said brake means to release said brake means when said access cover is opened.

7. Switch operating mechanism according to claim 6 wherein

said drive motor is connected to an electric current source, and

switch means operated by said access cover on opening thereof prevent energization of said drive motor from said electric current source.

8. Switch operating mechanism according to claim 1 wherein

said manually operable drive means includes hand crank receiving means, and

a shutter overlies said hand crank receiving means.

9. Switch operating mechanism according to claim 8 wherein

a manually operable selector handle is connected to said clutch shift means, and

shoulder means on said shutter engage said handle to prevent movement of said shutter out of overlying relation to said hand crank receiving means until said clutch shift means is operated by said handle to declutch said motor drive and auxiliary clutches.

10. Switch operating mechanism according to claim 8 wherein

said drive motor is connectable to an electric current source, and

switch means operated by said shutter when it is moved out of overlying relation to said hand crank receiving means disconnect said drive motor from said electric current source.

11. Switch operating mechanism according to claim 1 wherein locking means is engageable with an interlock stop rotatable with said drive shaft to prevent rotation thereof.

12. Switch operating mechanism according to claim 11 wherein

a shutter overlies said interlock stop to permit locking engagement therewith by said locking means only in said predetermined angular position of said drive shaft, and

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drive means interconnect said shutter and said auxiliary shaft.

13. Switch operating mechanism according to claim 12 wherein

said drive motor is connectable to an electric current source, and

switch means operated by said locking means when in locking engagement with said interlock stop prevents energization of said drive motor from said electric current source.

14. Switch operating mechanism according to claim 1 wherein

an index is mounted on said auxiliary shaft for rotation therewith,

another index is mounted on said control shaft for rotation therewith, and

a handwheel is connected to said drive motor for manually rotating it to align said indexes and thereby locate said motor drive and auxiliary clutches in clutchable relation.

15. Mechanism for operating a high voltage switch between open and closed positions at relatively high speed and requiring the application of relatively high torque in a relatively short interval comprising

a drive shaft for connection to said switch and rotatable through a plurality of rotations in opposite directions to effect opening or closing thereof,

an auxiliary shaft rotatable through less than one revolution about an axis parallel to the axis of rotation of said drive shaft,

a reduction gear train interconnecting said drive shaft and said auxiliary shaft,

a control shaft rotatably mounted on said auxiliary shaft,

a drive motor,

a gear train having the same reduction as the first mentioned gear train interconnecting said drive motor and said control shaft,

a motor drive clutch for connecting said drive shaft to said motor,

an auxiliary clutch between said auxiliary shaft and said control shaft and engageable only when said drive shaft is rotated about its axis to a predetermined angular position with respect to the angular position to which said control shaft is rotated about its axis by said motor,

manually operable drive means rotatably mounted on said drive shaft,

a manual drive clutch for connecting said drive shaft to said manually operable drive means, and

clutch shift means commonly connected to said clutches for clutching and declutching said motor drive and auxiliary clutches and declutching and clutching respectively said manual drive clutch.

16. Switch operating mechanism according to claim 15 wherein

said drive motor is connected to an electric current source,

a switch open cam and a switch closed cam are mounted on said control shaft for rotation therewith,

a pivotally mounted cam follower is movable in opposite directions by said cams, and

limit switch means operated by said cam follower controls the deenergization of said drive motor at the ends of the opening and closing strokes of said high voltage switch.

17. Switch operating mechanism according to claim 15 wherein

a manually operable selector handle is connected to said clutch shift means,

brake means is connected to said drive motor for stopping it on deenergization thereof, and

brake release means interconnects said selector handle and said brake means for releasing the same when

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said selector handle operates said clutch shift means to declutch said motor drive clutch.

18. Switch operating mechanism according to claim 15 wherein

a handwheel is connected to said drive motor for manually rotating it,

an access cover overlies said handwheel,

connecting means between said access cover and said brake release means release said brake means when said access cover is opened, and

lost motion clutch means forming a part of said brake release means permit release of said brake means on opening of said access cover independently of release of said brake means by said selector handle.

19. Switch operating mechanism according to claim 15 wherein

said motor drive clutch includes

a motor clutch drive member connected to said drive motor, and

a motor clutch driven member slidably and non-rotatably mounted on said drive shaft,

said auxiliary clutch includes

a first auxiliary clutch member connected to said control shaft, and

a second clutch member slidably and non-rotatably mounted on said auxiliary shaft,

said manual drive clutch includes

a manual clutch drive member rotatably mounted on said drive shaft, and

a manual clutch driven member slidably and non-rotatably mounted on said drive shaft, and

said clutch shift means includes

a pivotally mounted clutch shift member pivotally connected to said motor clutch driven member, to said second auxiliary clutch member and to said manual clutch driven member.

20. Switch operating mechanism according to claim 19 wherein

said motor drive clutch members and said auxiliary clutch members have engageable teeth of different arcuate lengths to permit operative engagement therebetween only in said predetermined angular positions of said drive and control shafts, and

said teeth of said auxiliary clutch members have greater clearance therebetween than the clearance between said teeth on said motor drive clutch members.

21. Mechanism for operating a high voltage switch between open and closed positions comprising

a drive shaft for connection to said switch and rotatable in opposite directions to effect opening and closing thereof,

a rotatable auxiliary shaft,

a driving connection between said drive shaft and said auxiliary shaft,

a control shaft rotatable coaxially with said auxiliary shaft,

a drive motor,

a driving connection between said motor and said control shaft,

means driven by said control shaft for controlling said drive motor,

index means on said auxiliary shaft and on said control shaft to indicate the relative axial positions thereof,

a driving connection between said drive shaft and said drive motor including a motor drive clutch,

means preventing engagement of said motor drive clutch except when said drive shaft is in a predetermined angular position with respect to the angular position of said control shaft, and

clutch shift means connected to said motor drive clutch for clutching and declutching it to connect said drive shaft to and from said drive motor.

22. Switch operating mechanism according to claim 21 wherein

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said drive motor is connectable to an electric current source, and
 said means driven by said control shaft comprises limit switch means for controlling the deenergization of said drive motor at the ends of the opening and closing strokes of said high voltage switch.

23. Switch operating mechanism according to claim 21 wherein auxiliary switch means is operated by said auxiliary shaft in accordance with the position of said high voltage switch.

24. Switch operating mechanism according to claim 21 wherein

brake means is connected to said drive motor for stopping it on deenergization thereof, and
 means is connected to said brake means for releasing the same when said drive motor is energized.

25. Switch operating mechanism according to claim 24 wherein means interconnect said clutch shift means and said brake means to release said brake means when said clutch shift means declutches said motor drive clutch.

26. Switch operating mechanism according to claim 21 wherein

said means includes

an index mounted on said auxiliary shaft for rotation therewith, and

another index mounted on said control shaft for rotation therewith, and

manually operable means is connected to said drive motor for manually rotating it to align said indexes and thereby place said motor drive clutch in clutchable position.

27. Switch operating mechanism according to claim 21 wherein

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said drive motor is connectable to an electric current source,

a switch open cam and a switch closed cam are mounted on said control shaft for rotation therewith,

a pivotally mounted cam follower is movable in opposite directions by said cams, and

said means driven by said control shaft comprises limit switch means operated by said cam follower for controlling the deenergization of said drive motor at the ends of the opening and closing strokes of said high voltage switch.

28. Switch operating mechanism according to claim 21 wherein

a manually operable selector handle is connected to said clutch shift means,

brake means is connected to said drive motor for stopping it on deenergization thereof, and

brake release means interconnects said selector handle and said brake means for releasing the same when said selector handle operates said clutch shift means to declutch said motor drive clutch.

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